PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DELMOE LAKE DAM
BUTTE, MONTANA
JEFFERSON COUNTY
MT-117

PREPARED FOR:

HONORABLE THOMAS L. JUDGE
GOVERNOR, STATE OF MONTANA

PIPESTONE WATER USERS ASSOCIATION
(OWNER AND OPERATOR)

PREPARED BY:
CH2M HILL
BELLEVUE, WASHINGTON

APRIL 1980

SEATTLE DISTRICT
UNITED STATES ARMY CORPS OF ENGINEERS

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EXECUTIVE SUMMARY

Under contract with the Seattle District Corps of Engineers, and with representation from the Corps, the State of Montana Department of Natural Resources and Conservation, the U.S. Forest Service, and the Pipestone Water Users Association, CH2M HILL inspected Delmoe Lake Dam on June 7, 1979, under the authority of Public Law 92-367. The dam is located on Big Pipestone Creek in Jefferson County, about 7 miles east of Butte, Montana.

This report was compiled from information obtained during an onsite inspection, review of construction plans, and analysis of available hydrologic information. Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction, and operation.

FINDINGS AND EVALUATION

Delmoe Lake Dam is owned and operated by the Pipestone Water Users Association. The dam and reservoir are located on private lands. However, when the reservoir reaches its maximum height, a portion of the upstream waters inundate Forest Service land. For this reason, a special use permit has been issued by the U.S. Forest Service. Delmoe Lake Dam is used primarily for storage of irrigation waters but is also used for recreation.

The 60-foot-high earth dam impounds 9,900 acre-feet of water at assumed top of the dam, elevation 6110 feet National Geodetic Vertical Datum (NGVD), previously Mean Sea Level (MSL). On the basis of criteria in U.S. Army Corps of Engineers Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is intermediate in size. The dam is located such that its failure could endanger many lives and cause extensive property damage. However, no dam breach analysis or routing of a dam breach flood was made for the downstream area. The conclusions on probable damage are based on a brief field visit and engineering judgment. The project is classified as having a high (Category 1) downstream hazard potential. Inspection criteria (Ref. 1) recommend that an intermediate-sized project with a high downstream hazard potential be capable of safely handling the probable maximum flood (PMF). The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region.

An estimated PMF was developed for the 22.9-square-mile drainage basin. Refinement of this estimate may either increase or decrease the final flood characteristics. The estimated PMF resulting from the 72-hour general storm has a volume of 21,200 acre-feet and a peak flow of 72,000 c.f.s. The spillway has a maximum discharge capacity of 1,900 c.f.s. with the reservoir at top of dam, elevation 6110 feet NGVD. Routing of the estimated PMF was started with the reservoir at spillway crest, elevation 6101.4 feet NGVD. The routing indicates that the dam is overtopped during the PMF when approximately 22 percent of the total flood volume enters the reservoir. The dam is constructed of materials that would quickly erode and rapidly fail when overtopped by floodwaters. Such failure would endanger many lives and cause extensive property damage.

On the basis of the field inspection and preliminary hydrologic analysis, Delmoe Lake Dam does not now conform to inspection guidelines with respect to discharge and/or storage capacities to safely handle the PMF; this could lead to loss of life and property destruction. Based on inspection guideline criteria, the project is unsafe until the recommended actions are accomplished. The following existing conditions are additional problem areas affecting safe project operation:

- The spillway has no log boom.
- The spillway is an unlined chute that could be eroded by sustained discharges.
- Erosion and failure of the spillway retaining dike could result in spillway discharges reaching the dam embankment.
- Riprap is not adequate on the upstream face of the dam as vertical wave cut faces are common.
- The position of the seepage line on the downstream slope, together with evidence of particle migration due to seepage, suggests that stability of the downstream slope is inadequate.

An Interstate 90 roadfill crosses Big Pipestone Creek about 6.2 miles downstream of the dam. Preliminary estimates indicate that the roadfill could overtop during floods significantly smaller than the PMF without a failure of Delmoe Lake Dam; failure of this roadfill by overtopping could result in extreme property damage and loss of many lives.

RECOMMENDATIONS

Because of storage between normal pool and dam crest, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing protection.

A downstream warning system, for use in the event of possible dam overtopping or structural failure, must be developed and immediately placed in action. Construct a spillway log boom and reinforce the spillway dike to a point where its failure would not release flows onto the dam embankment. Inspect the entire length of both outlet conduits and repair as necessary. Provide adequately designed riprap on upstream face of dam.

Conduct engineering studies to evaluate embankment stability and to determine the detailed PMF. Modify the project as studies indicate for stability and capability to safely handle the PMF. Conduct periodic inspections of Delmoe Lake Dam at not more than 5-year intervals by engineers experienced in dam design and construction.

MONTANA
RICHARD L.
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REGISTERED
PROFESSIONAL ENGINEER

Richard L. Foster
Professional Engineer

PERTINENT DATA

1. GENERAL

Federal ID No.	MT-117
Owner	Pipestone Water Users Association
Operator	Same
Date Constructed	About 1923
Purpose	Irrigation
Location	Section 27, T3N, R6W Principal Meridian
County, State	Jefferson County, Montana
Watershed	Big Pipestone Creek
Downstream Hazard Potential	Category 1 (High)
USGS Quadrangle	Delmoe Lake

2. RESERVOIR

Surface Area at Spillway Crest	310 acres
Drainage Area	22.9 square miles
Storage at Spillway Crest, Elevation 6101.4 feet NGVD	6,800 acre-feet
Storage at Dam Crest, Elevation 6110 feet NGVD	9,900 acre-feet
Surcharge Storage	3,100 acre-feet

3. SPILLWAY

Type	Uncontrolled, unlined chute
Crest Width	25 feet
Crest Elevation	6,101.4 feet

Capacity with Reservoir at Dam Crest	1,900 c.f.s.

4. OUTLET WORKS

Conduits	Two 24-inch-diameter, concrete-encased steel conduits
Conduit Lengths	240 feet each
Valves	One 24-inch-diameter gate valve per conduit
Capacity with Reservoir at Dam Crest	150 c.f.s.

5. DAM

Type	Hydraulic fill with central concrete core
Length	290 feet
Crest Width	40 feet
Crest Elevation	6110 feet NGVD
Hydraulic Height (Crest to Toe)	60 feet
Upstream Slope	1 V on 3 H
Downstream Slope	1 V on 2 H

CHAPTER 1
BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority and Scope

This report summarizes the Phase I inspection and evaluation of Delmoe Lake Dam, owned by the Pipestone Water Users Association, Butte, Montana.

The National Dam Inspection Act, Public Law 92-367 dated August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-Federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many Federal and state agencies, professional engineering organizations, and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

The guidelines recommend a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam.
(2) based upon an evaluation of the available data and a visual inspection.
(3) performed to determine if any needed emergency measures and/or if additional studies, investigations, and analyses are necessary or warranted.
(4) not intended to include extensive explorations or analyses or to provide detailed alternative correction recommendations.

The details of Phase I recommendations must be developed in the Phase II investigation. The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam and to develop the detailed correction recommendations. Included in Phase II, as required, should

be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulics and hydrologic analyses, and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations, with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies, but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The Corps has no authority to enforce the recommendations contained in the safety reports. The responsibility for implementation of the Phase I recommendations or initiating the Phase II studies rests with the dam owner and the State of Montana. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this Act shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

1.1.2 Purpose

The purpose of the inspection and evaluation is to identify conditions that threaten public safety, so that they may be corrected in a timely manner by non-Federal interests.

1.1.3 Inspection

The findings and recommendations in this report are based on visual inspection of the project, and a detailed review of all available plans and previous inspections and studies. Inspection procedures and criteria were those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

Personnel present during the inspection included:

- R. D. Eckerlin, Geologist, Seattle District, U.S. Army Corps of Engineers
- Larry Tegg, State of Montana, Department of Natural Resources and Conservation
- Robert Clark, State of Montana, Department of Natural Resources and Conservation
- John Kountz, Director, Pipestone Water Users Association

John Smith, Pipestone Water Users Association

Ernest Tabay, Pipestone Water Users Association

CH2M HILL personnel who participated in the field inspection and contributed to this report are:

Miles C. Bubenik, Geotechnical Engineer, Team Leader

Jerry Jacksha, Geotechnical Engineer

Loren Bottorff, Hydrologist/Hydraulics Engineer

This report has been reviewed by the State of Montana Department of Natural Resources and Conservation; U.S. Forest Service, Missoula, Montana; and Pipestone Water Users Association. Their written comments are enclosed in the Appendix.

1.2 DESCRIPTION OF PROJECT

1.2.1 General

Delmoe Lake and Dam are located on Pipestone Creek, a tributary of the Jefferson River, in Jefferson County, Montana, approximately 7 miles east of Butte (see Plate 1). The dam was constructed in 1913-1914, and is currently listed as having high downstream hazard potential. The Federal identification number is MT-117. The 60-foot-high dam impounds 9,900 acre-feet at dam crest, elevation 6110 feet NGVD. The dam is located such that its failure would endanger many lives and cause extensive property damage to the downstream agricultural land and the I-90 roadway embankment approximately 6.2 miles downstream of the dam. On the basis of this information and in accordance with the Recommended Guidelines (Ref. 1), the project size is intermediate and the downstream hazard potential is high (Category 1).

The 310-acre lake is used for irrigation storage and recreation. Operation and maintenance are performed by the Pipestone Water Users Association.

The 300-foot-long spillway channel is located near the right abutment, as shown in Photos 1, 4, and 5, and on Plate 4. The two low-level outlet conduits each have a single 24-inch-diameter gate that controls irrigation releases (see Photos 5 and 6).

1.2.2 Regional Geology and Seismicity

Delmoe Lake is located within the Northern Rocky Mountains physiographic province, approximately 5 miles east of the

Continental Divide, 7 miles east of Butte, and within the Boulder batholith complex. Intrusion of the Boulder batholith occurred during the late Cretaceous, approximately 78 million years ago. Boulder batholith, which is elongated in the northeast direction, is a composite intrusive in which quartz monzonite is the dominant rock type.

In accordance with the Seismic Zone Map in the Recommended Guidelines (Ref. 1), the site is in Seismic Zone 3. The seismic probability of Zone 3 is one of potential for major damage and is based on known distribution of damaging earthquakes. Algermissen (Ref. 6) recommends design accelerations approaching 0.2 g, with 90 percent probability of not being exceeded in 50 years. The 1959 Hebgen Lake event, magnitude 7.5, was estimated to cause 0.1 g acceleration at the dam. Hebgen Lake is situated about 85 miles to the southeast. The closest historic seismicity was a magnitude 4.3 event, which occurred in 1959 about 13 miles to the southeast near Whitehall, Montana. Small events within 12 miles west of the dam are most probably related to blasting operations at the Butte mining district.

1.2.3 Site Geology

Delmoe Lake Dam spans the inlet of a canyon cut into granitic (quartz monzonite) bedrock. Both abutments consist of granitic (quartz monzonite) bedrock that has been rounded and smoothed by stream erosion. Bedrock exposed at the dam crest on the left (north) abutment contains widely spaced joints on the order of 1 to 10 feet. Exposed rock at the right (south) abutment is massive and relatively impervious. Rock texture on both abutments is medium to coarsely granitic with local zones showing potassium-feldspar phenocrysts. The area is characterized by numerous spires and pinnacles of granitic rock, jutting up through thin soil cover, with clumps of trees growing between them. These spires were apparently formed by extensive differential weathering of granite along fractures. Eventually, residuum that developed along these fractures was washed away, leaving the solid spires and pinnacles now seen.

The extent of foundation preparation is not known. Material used to construct the embankment was borrowed locally and consists of granitic residuum. The right spillway wall is composed of jointed and weathered granitic bedrock that rises about 20 feet above the channel floor. Two predominant joint sets occur, one set striking approximately north-south and dipping about 80 degrees east and the other set striking north-south and dipping 60 degrees west. Joint spacing ranges from 1 foot to 10 feet. According to construction details, the low-level outlet conduits are founded on the left abutment bedrock.

1.2.4 Design and Construction History

Lake Delmoe Dam was completed about 1923. A single drawing (Plate 5) depicts construction details. The State of Montana Department of Natural Resources and Conservation files contain no information on the foundation conditions, borrow materials for embankment construction, construction control records, stability analysis, or information on hydrology or hydraulics.

The state records include a number of inspection reports by staff engineers of the Forest Service.

CHAPTER 2
INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillway

The spillway for Delmoe Lake Dam is located in natural ground at the right abutment. The spillway consists of a 300-foot-long unlined chute (Photo 4) in decomposed granite and rock with a 25-foot bottom width. A concrete wall, flush with the invert of the chute, crosses the chute about 60 feet downstream of the entrance. The top of this concrete wall is 0.7 feet lower in elevation than the chute entrance. The chute entrance invert is at elevation 6101.4 feet NGVD (based on an assumed top of dam elevation 6110 feet NGVD). At the spillway entrance, the right (looking downstream) bank has a side slope of about 1 H on 1 V but changes to near vertical for most of the length. The left (looking downstream) chute bank is cemented-in-place, vertically stacked rock from the chute entrance downstream for about 100 feet. The remaining 200 feet of the left chute bank is an earth (decomposed granite) rock dike about 6 feet high with approximately 1 H on 1 V side slopes (Photo 5). The chute makes a gradual bend to the right for its 300-foot length. The chute discharges over a steep bank protected with large riprap (some erosion exists). The chute slope averages 0.04 feet per foot downstream of the concrete wall.

The spillway rating was developed by assuming that critical depth occurs at the chute entrance. Backwater computations in the spillway chute, using a Manning's "n" of 0.025, revealed that the control remains at the chute entrance for all discharges. An energy loss of 0.3 times the velocity head was used to account for channel entrance conditions. The maximum discharge capacity of the spillway with the reservoir at the top of dam, elevation 6100 feet NGVD, was estimated to be 1,900 c.f.s. The discharge rating curve is presented on Plate 3.

Sustained spillway discharges will cause erosion of the chute floor and the retaining dike. Failure of the dike 80 to 100 feet downstream of the chute entrance could cause flows to reach the dam embankment. Erosion of the dam embankment could result in failure. Also, a low point on the dike at this location may be overtopped by discharges less than the maximum computed discharge. The erosion at the downstream end of the chute does not affect dam safety.

2.1.2 Outlet

The outlet works for Delmoe Lake Dam is located through the embankment near the center of the dam. Two 24-inch-diameter, concrete-encased steel conduits, believed to be founded on rock, extend 240 feet (0.0049 slope) from the intake structure to the outlet structure. The intake structure is combined with the gate tower and is located in the reservoir about 125 feet from the axis of the dam. Each conduit is controlled by a 24-inch-diameter gate valve operated from the top of the tower. The tower is covered by a gatehouse and is reached by a cable and wood walkway from the left abutment of the dam. The tower was not entered during the inspection. Previous inspection reports indicate considerable erosion exists of valves and appurtenant metal, and that valves could not be completely or easily closed.

The outlet structure consists of a pair of parallel concrete walls crossed by a 3-foot-high concrete sill about 10 feet downstream of the end of the conduit. Before exiting to the natural channels, the discharge spills over the sill to a concrete-lined plunge pool with an invert 5 feet below the conduit invert (Plate 4).

Detailed inspection of the conduits and the outlet structure could not be made because of discharge through the outlet works. The concrete of the outlet structure contained cracking and heavy spalling but does not currently endanger the safety of the dam. Rock has been stacked along the outlet channel downstream of the dam as erosion protection.

The outlet works was rated with both valves fully open. A Manning's "n" of 0.016 was used to estimate friction losses with the conduits flowing full. The maximum discharge capacity of the outlet works, with the reservoir at the top of dam, elevation 6110 feet NGVD, was estimated to be 150 c.f.s.

2.1.3 Freeboard

Because the dam overtops during the probable maximum flood (PMF, see paragraph 2.2.4), it has no freeboard. The vertical distance between the low point on the dam and the reservoir level at the time of the inspection was 8.8 feet. The spillway crest is 8.6 feet below the low point on the dam crest. The crest of the dam varies 1 foot over its 290-foot length. The effective fetch for wind-generated waves is about 2,000 feet and wave runup on the embankment is estimated to be approximately 3 feet. Although the dam will overtop during the PMF, the vertical distance between the dam crest and the normal reservoir level is adequate to prevent overtopping the embankment by wind waves.

2.2 HYDROLOGY, CLIMATOLOGY, AND PHYSIOGRAPHY

2.2.1 General

The climate of the area is continental in nature, characterized by warm summers, cold winters, and a semiarid precipitation regime. The nearest climatological station (elevation 5540 feet NGVD) is at Butte, about 7 miles west of the Delmoe Lake drainage basin. Mean annual precipitation at the station is 12.2 inches, with 65 percent falling from May through September. Mean February precipitation is 0.39 inches and mean June precipitation is 2.69 inches. Mean annual precipitation on the Delmoe Lake drainage basin is probably approximately 12 inches. Mean annual temperature at Butte is 38.4 degrees F, mean January temperature is 15.1 degrees F, and mean July temperature is 62.2 degrees F. Temperatures on the Delmoe Lake drainage basin probably average about 6 degrees cooler than Butte. Occasionally, summer temperatures exceed 100 degrees F and winter temperatures dip below -40 degrees F. Winters have few extended cold spells; periods of warm, windy "chinook" weather occur between cold spells.

The drainage basin area is 22.9 square miles and is roughly oval in shape. The basin is on the east slope of the Continental Divide and is bounded on the west by it. Basin elevations range from 6110 feet to 8625 feet; the area is mountainous and fully forested. Three main creeks enter Delmoe Lake. There are no gauges of reservoir inflow or outflow.

2.2.2 Reservoir Storage and Spillway Discharge

The reservoir has a surface area of 310 acres and a storage of 6,800 acre-feet at spillway, elevation 6101.4 feet NGVD. Approximately 3,100 acre-feet of surcharge storage is available in the reservoir between the spillway crest and the dam crest. The spillway discharge with the reservoir at the dam crest is 1,900 c.f.s., or about 160 acre-feet per hour.

2.2.3 Estimated Probable Maximum Flood

The probable maximum flood (PMF) is the flood expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. An estimate of the PMF was made during this dam safety analysis and was routed through the reservoir.

The procedure contained in U.S. Weather Bureau's Technical Paper 38 (Ref. 2) was used to compute the probable maximum precipitation (PMP). This storm for the 22.9-square-mile

drainage area produces 9.9 inches in 6 hours, and 14.3 inches in 24 hours. The 72-hour precipitation was estimated to be 16.5 inches.

Frozen ground, no infiltration losses, and a base flow of 175 c.f.s. were used for the entire flood.

A triangular unit hydrograph for a 15-minute rainfall duration was developed for the 22.9-square-mile drainage basin by procedures outlined in Design of Small Dams (Ref. 3). A curvilinear fit of the triangular unit hydrograph was used. The PMP was applied to the unit hydrograph by means of the computer program, HEC-1 (Ref. 4). This estimate of the PMP produced a flood with a peak flow of 72,000 c.f.s. and a volume of 21,200 acre-feet.

2.2.4 Flood Routing

The PMF was routed through the reservoir by using the computer program HEC-1 (Ref. 4). The reservoir level was assumed to be at the spillway crest at the beginning of the PMF. The outlet works was assumed to be fully open during the entire flood. The routing shows that the dam will be overtopped during the PMF when approximately 22 percent of the total flood volume enters the reservoir. Floods much smaller than the PMF will overtop and fail the dam.

The Interstate 90 roadfill, located across Big Pipestone Creek, 6.2 miles downstream of the dam, has a storage of 2,600 acre-feet compared with the total 9,900 acre-feet storage in Delmoe Lake. The 8-foot-diameter CMP culvert can pass a maximum of 1,630 c.f.s., but this culvert could easily become clogged during a major flood. A major storm, centered mainly over the Delmoe Lake basin, would cause Delmoe Lake Dam to fail with subsequent overtopping of the I-90 roadfill. The I-90 roadfill has a drainage area of about 75 square miles, 52 miles of which do not drain into Delmoe Lake. A major storm, centered mainly over the area not draining into Delmoe Lake, would still cause overtopping of the I-90 roadfill; however, without failure of Delmoe Lake Dam. A major storm, encompassing the whole area, would probably overtop the I-90 roadfill prior to overtopping Delmoe Lake Dam.

2.3 GEOTECHNICAL EVALUATION

2.3.1 Dam

The 60-foot-high zoned earthfill dam is 290 feet long and has a 40-foot crest width at elevation 5785 feet NGVD. The

upstream slope is 1 V on 3 H and the downstream 1 V on 2 H. Sketchy construction plans (Plate 5) show a central concrete diaphragm; however, plans are not clear whether the concrete diaphragm was extended to rock. The concrete diaphragm thickness varies from 4 feet at the base to 6 inches for the upper 40 feet. Plans show that the select material adjacent to the concrete diaphragm was sluiced into place and met gradation requirements of 70 percent silt and sand and 30 percent clay. Materials both upstream and downstream of the select material core are shown as sand and gravels sluiced into place.

There is no information on depth or type of foundation soils. Borrow material for embankment construction apparently was obtained from the bench area above the right abutment and from above the left abutment, as evidenced by construction scars.

The embankment slopes and crest were uniform with no evidence of subsidence, slumps, or cracking.

The upstream slope has an 18-inch thickness of rock riprap. The riprap was apparently placed on the sand embankment material without a bedding or filter layer and as a result, some erosion has taken place, forming a scarp approximately 3 feet high.

The downstream embankment toe is heavily wooded.

2.3.2 Foundation Conditions, Seepage, and Drainage

As stated in paragraph 1.2.3 Site Geology, rock at both abutments is granite, massive, and relatively impervious. Neither depth to bedrock in the valley floor, nor the extent of foundation preparation has been determined.

Seepage emerging from the embankment slope was observed along the entire downstream toe area. Flow was estimated at about 60 g.p.m. The steepened slope at the toe and delta-like formation at spring areas are evidence of past particle migration.

Plate 2 shows the locations of seven piezometers installed in 1970 by the Soil Conservation Service. The piezometers are not functioning and data from past observations are not available.

2.3.3 Stability

Guidelines for dam safety inspections (Ref. 1) recommend that stability analyses be on file for all dams in the high

hazard category. Based on a review of available information, it is our judgment that Delmoe Lake embankment stability does not conform with the Corps guidelines.

The high phreatic surface in the downstream embankment slope, the probable low-density sandy embankment materials that are the result of sluicing material into place, and the seismic probability of Zone 3 for major damage (including possibility of liquefaction) are the principal factors adversely affecting embankment stability.

2.4 PROJECT OPERATION AND MAINTENANCE

The facility is owned and operated by the Pipestone Water Users Association. Information on operations and maintenance was obtained from discussions with members of the Water Users Association, since formal project operation and maintenance programs for the dam do not exist.

2.4.1 Dam

Maintenance of the dam is performed as required. Maintenance of the intake structure, including cleaning rock and mud from the approach channel, was performed in 1971 when the reservoir was drawn down. According to Forest Service records, additional repairs were made to the gate valves and valve stems. The riprap on the upstream face of the dam requires maintenance. The intake tower was not inspected to determine whether corrosion of the valves and appurtenant metal (including steel conduits), mentioned in previous inspection reports, has been remedied.

2.4.2 Reservoir

Delmoe Lake is used primarily for storage of irrigation water, but it also receives heavy recreational use. The water users had a fulltime dam operator until the beginning of 1979; currently the water users operate the dam. The valves are operated as needed for irrigation releases. Typically, the reservoir is emptied by the end of the irrigation season. The reservoir seldom reaches the spillway crest. The U.S. Forest Service special use permit for Delmoe Lake restricts maximum storage elevation to a point 7 feet below the spillway elevation, but this restriction has never been enforced.

2.4.3 Warning System

There is no formal warning plan for use in the event of impending dam failure.

CHAPTER 3
FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam and supplemental analysis of the project in terms of the recommended guidelines' performance standards resulted in the following findings.

3.1.1 Size, Hazard Classification, and Safety Evaluation

In accordance with inspection guidelines, Delmoe Lake Dam is intermediate in size and has a high downstream hazard potential rating. The guidelines recommend that a dam with the above classification be capable of safely handling a spillway design flood of 100 percent of the PMF. Because the project is incapable of controlling one-half the PMF without overtopping and causing the dam to fail, Delmoe Lake Dam is considered unsafe until recommended actions are completed.

3.1.2. Embankment Dam

A brief visual inspection of Delmoe Lake Dam showed the embankment slopes uniform with no obvious depressions, bulges, or cracking. Toe seepage extended from abutment to abutment and was accompanied by slope steepening at the toe and some evidence of particle migration. Seepage quantity was about 60 g.p.m. with the pool near spillway crest.

Both the upstream and downstream slopes support a sparse covering of small brush, and the downstream toe supports a thick cover of brush and trees.

Riprap protection on the upstream slope was placed without adequate bedding or filter protection, and erosion is occurring as a result, as evidenced by a 3-foot scarp near spillway crest elevation.

Embankment stability does not conform with the recommended guidelines for either the static condition, as evidenced by a high phreatic surface in the embankment, or for the Zone 3 seismic condition that could lead to liquefaction failure of the hydraulically placed sand embankment.

3.1.3. Spillway and Reservoir Capacity

The reservoir has a surface area of 310 acres and a storage of 6,800 acre-feet at assumed spillway elevation 6,101.4 feet NGVD. Approximately 3,100 acre-feet of surcharge

storage is available in the reservoir between the spillway crest and the dam crest. The discharge of the spillway, with the reservoir at the dam crest, is 1,900 c.f.s.

In addition to a seriously inadequate spillway, the following existing spillway conditions could affect safe operation: (a) the spillway has no log boom; (b) the unlined spillway channel may be heavily eroded by sustained discharges; and (c) the dike along the left (looking downstream) side of the channel may erode and cause spillway flows to infringe upon the dam embankment.

3.1.4 Outlet Works

Inspection of the outlet conduits and intake the structure could not be made because of reservoir level. The portion of the outlet structure that could be seen contained cracking and heavy spalling. It does not currently endanger the safety of the dam. Rock has been placed along the outlet channel for erosion protection.

3.1.5 Operation and Maintenance

The facility is owned and operated by the Pipestone Water Users Association. Maintenance of the dam is performed as required. The outlet valves are operated as needed for irrigation releases. There is no formal warning plan for use in the event of impending dam failure.

3.2 RECOMMENDATIONS

Because of storage between normal pool and dam crest considerations, the present project provides a degree of flood protection to the downstream area. The intent of report recommendations is to maintain or improve project safety, if feasible, without decreasing this existing flood protection.

1. Immediately develop, implement, and periodically test an emergency warning plan for use in the event of impending dam overtopping or structural failure.

2. Construct a log boom to protect the spillway from floating debris.

3. Reinforce and raise, as required, the left bank spillway dike to minimize potential for overtopping and/or failure during spillway operation to prevent discharge flows on the dam embankment.

4. Inspect the entire length of both outlet conduits and repair as necessary.

5. Repair or replace outlet valves and appurtenant metal as required.

6. Repair riprap on upstream face of dam and provide adequate bedding.

7. Remove all brush and trees from dam and toe areas and properly backfill disturbed areas.

8. Regrade the downstream toe area and provide a toe berm with filter protection. This work must be directed by a qualified geotechnical engineer experienced in dam design.

The above recommendations will not make the dam safe, but they will reduce risk to life and property while the following recommended actions are being taken.

9. Conduct engineering studies to determine the detailed PMF. Include in this study a dam breach and downstream flood routing to better define downstream hazards. Modify the discharge and/or storage capacity to safely handle the full PMF.

10. The downstream phreatic surface needs to be defined by the installation of piezometers. Obtain and test soil samples from piezometer borings to define soil characteristics and strengths of embankment and foundation.

11. Conduct a seismic study and determine the design earthquake and acceleration.

12. Conduct stability analysis using acceleration established by the seismic study and strength properties from testing. Analysis must consider the possibility of liquefaction or strength loss during earthquake. Modify the embankment section as required to provide the safety established by the recommended guidelines (Ref. 1).

13. Conduct periodic inspections of Delmoe Lake Dam at not less than 5-year intervals by engineers experienced in dam design and construction.

14. Install and monitor seepage weirs.

REFERENCES

1. U.S. Army Corps of Engineers, Office of the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams," Washington, D.C., Department of the Army, May 1975.

2. U.S. Weather Bureau, Technical Paper 38, Generalized Estimates of Probable Maximum Precipitation for the United States West of the 105th Meridian, Washington, D.C., 1960.

3. U.S. Bureau of Reclamation, "Design of Small Dams," 2nd Edition, 1974.

4. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Davis, California, January 1973.

5. R. D. Eckerlin, U.S. Army Corps of Engineers geologist, Memorandum on Delmoe Lake and Dam Inspection, July 1979.

6. S. T. Algermissen and D. M. Perkins, "A Probabilistic Estimate of Maximum Accelerations in Rock in the Contiguous United States," Bulletin, U.S. Department of the Interior, open file report, U.S. Geological Survey, No. 76-416, 1976.

APPENDIX

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR 32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872 HELENA, MONTANA 59601

February 19, 1980

Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Attn: Mr. Ralph Morrison

Re: CH_2M Hill Dam Safety Inspection report on Lake Delmoe Dam MT-117.

Dear Ralph:

We have reviewed the final draft report on the above referenced dam and have found the report to be satisfactory with exception of the following:

(1) In the Executive Summary under Findings and Evaluations on page iii in the first paragraph it is stated that the dam will overtop when approximately 22 percent of the PMF volume has entered the reservoir. Following this, a statement should be added as to what percentage of the PMF (ordinate method) will cause overtopping. This statement should also be added in the first paragraph of Section 2.2.4 Flood Routing, in the third paragraph of Section 2.5 Safety Evaluation, and in the second paragraph of Section 3.1.3 Spillway and Reservoir Capacity.

(2) In Sub-Section 2.3.1 Dam; the fourth sentence in the first paragraph reads "The plans are not clear whether the concrete diaphragm was extended to rock.". This sentence should be clarified since the previous sentence states that the concrete diaphragm is founded on rock throughout the length of the low-level outlet and control tower.

(3) It appears that the I-90 roadway fill 6.2 miles downstream of Delmoe Lake Dam may be more of a hazard than Delmoe Lake Dam since it is a high fill and can be overtopped by a PMF even without the failure of Delmoe Lake Dam. To add weight to this, the majority of the inhabitable structures below Delmoe Lake Dam are downstream of the I-90 roadway fill.

We thank you for the opportunity to review this report.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau

RB:LT:mb

February 22, 1980

Honorable Thomas L. Judge
Governor, State of Montana
State Capitol
Helena, Montana

RE: Delmo Lake Dam,
Jefferson County, Whitehall, Mt.
Phase I Inspection Report
National Dam Safety Program
M.T.-117-Pipestone Water Users' Assn., Inc.

Dear Governor Judge:

The Board of Directors and Officers of the Pipestone Water Users' Assn., Whitehall, Montana respectfully respond to the Final Draft of the Inspection Report submitted to your office at a prior date. The Association did not receive copies until recently and was, therefore, unable to examine the report and make its response until this time.

To understand the Association's position it requires some background history and management policy explanation. With as much brevity as possible, we indulge your patience and time in reading this summary hopefully to assist you in your evaluation and judgment of this subject.

Within the legal timeframe, the President of the Association, Mr. John Kountz, (not Counts, as stated in the report) issued a call for a special meeting which was held in Whitehall, January 21, 1980 for the purpose of reviewing the Inspection Report. At this time, the report was read in its entirety. The officers and members commented fully on each phase set forth therein, and as a result thereof, the President and Directors were instructed to respond in the following manner.

In the year 1942, the Pipestone Water Users Association was incorporated as a non-profit organization for the purpose of purchasing Delmoe Lake Reservoir. There were fourteen stockholders all of which were farmers and ranchers and sole users of the stored water.

Contrary to the statement on Page i of the inspection report, the dam and reservoir are located on private land and not U.S. Forest Land. There is, however, some invasion of water on forest land when the reservoir reaches its maximum height. For this invasion, a special use permit has been issued by the Forest Service. A title insurance policy was issued on this land at it has been taxed as such since its construction. At the time of incorporation, the reservoir provided irrigation water to 1,860 acres all owned by the stockholders. This acreage has since increased by many acres. To assure reasonable amounts of water,stock was sold on the basis of the known lowest amount of stored water, which was 2,300 acre feet. This permitted the Association to assure delivery of 1 acre foot of water per share of stock. History shows under the Association's management, upwards of two and a quarter acre feet have been delivered per share of stock.

The dam was constructed in the years 1913-1914, not in the year 1923 as stated incorrectly on page 5 of the Inspection Report. Contrary to the impression stated in said Report, the reservoir does not store 9,900 acre feet for the obvious reason that the spillway is approximately nine feet below the crest of the dam. The true capacity of the reservoir is 6,585 acre feet. (See Water Resources Survey, State Engineers Office 1956). We are aware of the Guideline for Safety Inspection, App. D.

During the thirty-eight years of ownership and operation by the Association, the economic value of the project has proven itself many times, not only to the owners by reason of the use of the stored water but to the community. The town of Whitehall, County of Jefferson and State of Montana has benefited by providing a stable and increasing agricultural and tax base, while the business community of Whitehall has been able to stabalize itself in the face of many small towns suffering steady decline.

There has been no profit to the stockholders of the Association except by reason of the benefit of the water to their crop lands.

An important fact which should not be overlooked is that the area involved is semi-arid. The average precipitation being 11.26 inches with the low of 6.00 inches, making this area lower in precipitation than any of the surrounding areas surveyed.

It should not be overlooked that, with small exceptions, all of the area in the alleged flood plain to the Town of Whitehall is owned and occupied by stockholders who would, in event of a flood, suffer the greated damage. There is not a large human habitation within this area.

The nature of the Association's operation is solely for irrigation purposes. This requires a steady draw down of the water. The Association has a 7,000 inch 1910 court decreed water right. This right is subsequent to earlier rights and as a result, the early rights must be discharged and not held to inrease the impounded water. The practical and historical results are that, water is discharged beginning in the months of April and May of each year and the surface area of the reservoir is not increased. During the months beginning with May, impounded water is released in amounts consistant with demand and the impounded water is used until late fall. At this time, the draw down on the impounded water has reduced the water level to a minimum. A period of six months is required to rebuild the impounded water to its capacity of 6,585 acre feet, which in many years is not attained. It is obvious, therefore, that only two months of twelve, there may exist a critical period whereby flooding may occur. According to the State Engineer Report (supra) the heaviest rainfall occurs in May and June, this being the period of time when draw down of this stored water has begun. Thirty-six years of continuous operation has proven the correctness of this conclusion.

If this project failed or was shut down, no one could be more concerned nor does any one have more to lose than the stockholders of the Pipestone Water User's Association. Their desires are not only to operate a safe project but to perform in accordance with this goal. This being a corporation with very few members, and all being constantly interested and involved and being dependant for their livelihood upon it, take unusual interest in the operation. Without this project, their properties would be waterless by mid-summer in most instances and would not sustain their farming operation. The Association has a continuing policy of improvement and has proceeded in a reasonable manner to accomplish its goals, such as establishing a new spillway which has proven itself in conjunction with water management, reinforcing the concrete tower, replacing the discharge gates, cooperating and consulting with the S.C.S., retaining the services of a private qualified engineering firm, performing routine inspections consisting but not limited to twice yearly removal of debris from spillway and structures and dam preservation.

The Association has determined that certain reinforcement and rip-rapping of a small portion of the dam and spillway is necessary and it will be accomplished as a next step in its maintenance program.

It is not the Association's purpose to be critical of the inspection report and our disagreement with certain provisions are based on other information and data which we believe is more reliable. It will be noticed in the Inspection Report that many assumptions are made and we believe that assumptions are only as sound as the facts upon which thay are made. The engineering firm of Morrison-Maierle, Inc., Helena, Montana in making a survey for the Association in 1971, stated in making its hydrologic study that based on stream flow records in areas adjacent to Delmoe Lake as follows: "The drainage area above Delmoe Lake comprises 23 square miles immediately south and west of the Boulder River Basin. If the drainage area above Delmoe Lake was as productive as the Boulder River Basin in the 1948 flood, a peak discharge of about 690 CFS could have been expected. Since the final design should be conservative, a hypothetical flood with a peak discharge of 1000 CFS was selected. The probability that a discharge equal to 1000 CFS will occur in the Delmoe watershed in any one year is on the order of 1 in 1000. In other words,a 1000 CFS flood could be expected about once in every 1000 years." The report analyzed three hypothetical conditions based on actual flood data and Forest Service requirements, the report continues, "with each of the three floods analyzed, the existing spillway proved capable of discharging enough water to prevent overtopping of the dam." A copy of this engineering report is available to you if desired. The Estimated Probable Maximum Flood as set forth in the Inspection Report is not based on actual or even probable facts but rather on a technical paper of the Weather Bureau which is entirely and completely refuted by the actual facts set forth in the Morrison-Maierle report.

The Associations feels that the Inspection Report confirms the stability and integrity of the dam wherein it is stated on page 17 "the embankment slope and crest were uniform with no evidence of subsidence, slumps, or cracking" and again on page 20 " The reservoir seldom reaches the spillway crest." What greater proof of good management is needed?

The Inspection Report indicates that the Interstate I-90 crossing creates a much greater flood potential wherein the

drainage basin is twice the area of the reservoir and as great a damage by a much smaller storm.

The Association desires to respond to the Recommendations 3.2 page 26 of the Inspection Report.

1. Immediately develop an emergency warning plan. The Association concludes that the greatest danger is from the I-90 roadfill as stated in the Inspection Report. Therefore, the State of Montana should determine the necessity and installation of such a system. The Association will cooperate to the extent of its involvement if an acceptable plan can be developed.

2. Construct a log boom. The Association cannot accept the proposal for the reason that its present management of physical removal of debris has proven more effective.

3. Reinforce left bank spillway. The Association has plans to correct this and it will be accomplished within the near future.

4. Inspect outlet conduits. This was initiated and completed prior to the inspection.

5. Repair outlet valves. New valves were installed and operable before the inspection.

6. Repair riprap on face of dam. This recommendation is included in the present maintenance plans and will be accomplished in the near future.

7. Remove all brush and trees, etc. This has been accomplished and will be done continually in the maintenance program.

8. Regrade downstream toe, etc. This is included in the maintenance program and will be accomplished in the near future.

9. Conduct engineering studies. This recommendation fails to consider the engineering studies previously conducted and it is the Associations belief that it is in full compliance with these engineering studies.

10. State of Montana conduct studies, etc.
This is the responsibility of the State. The Association feels it inappropriate to comment.

11. Downstream phreatic surface.
This comment presents no new information to the Association. It has acted on engineering advice and is constantly watched. If competent engineering advice is suggested, the Association will seriously consider such suggestions and take such action as deemed necessary.

12. Conduct a seismic study, etc.
The Association has not been advised by competent engineering advice that this is necessary.

13. Conduct Stability analysis, etc.
The Association believes the inspection report does not justify this procedure.

14. Conduct periodic inspections.
Timely inspections will be made upon advice of competent engineers.

15. Install and monitor seepage weirs.
This will be done upon advice of competent engineers.

16. Under this recommendation, we should like to comment that we have examined and noted carefully the pamphlet entitled Recommended Guidelines for Safety Inspection of Dams, Appendix D. While we believe it is a commendable effort to establish uniformity for inspections, we do not believe uniformity can be applicable to every structure wherever located and under very different conditions. Technical papers must be tempered with actual knowledge and conditions. Sixty-seven years of good management has proven without doubt the ability of the structure to stand safely against all known or anticipated conditions.

The Association strongly objects to the Possible Maximum Flood conclusion made in the report. It is based on technical weather bureau papers and computer analysis which have been domonstratively proved in error by the Morrison Engineering Study.

Respectfully submitted,

PIPESTONE WATER USERS ASSN.
Whitehall, Mt.

John Kountz
President

cc Department of Army
Seattle Dist. Corp. of Eng.
Box C-3755
Seattle, Wa. 98124

Sidney Knutsen P.C.
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Department of Natural Resources
and Conservation
State Capitol
Helena, Mt. 59601

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX C-3755
SEATTLE, WASHINGTON 98124

NPSEN-FM

25 MAR 1980

John Kountz, President
Pipestone Water User's Association
Whitehall, Montana 59759

Dear Mr. Kountz:

Thank you for your comments on the draft dam safety report on Delmo Lake Dam. The report will be corrected to show proper name spellings, U. S. Forest Service land use and year of construction. The maximum storage, storage to dam crest, is used when computing total storage possible at any project.

Our probable maximum flood (PMF) derivation is an estimate based on accepted procedures and, although floods approaching the PMF may have never been historically experienced in your area, represents what could happen. Refinement of our estimate is a recommendation that could either increase or decrease the final flood characteristics.

Uniform crest elevation and embankment slopes may suggest that a dam is stable, but seepage noted during the inspection and the probable low density of sluiced materials raise questions in our minds as to the actual stability of the dam under all conditions. The outlet valves and conduits must be inspected frequently; to the best of our knowledge, they have not been inspected for many years.

The report recommendations require review, discussion and coordination between you and the Engineering Bureau of the Montana Department of Natural Resources and Conservation for resolution prior to any implementing action.

Sincerely yours,

Edward

SIDNEY KNUTSON, P.E.
Asst. Chief, Engineering Division

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FEDERAL BUILDING MISSOULA, MONTANA 59801

(7530)
J. . 8 1980

Sidney Knutson, P.E.
Assistant Chief, Engineering Division
Department of the Army
Seattle District, Corps of Engineers
P. O. Box C-3755
Seattle, Washington 98124

Dear Mr. Knutson:

As requested in your letter of January 3, we have reviewed the final draft report on Delmoe Lake Dam and have the following comments.

1. It should be noted that the dam and most of the reservoir are on private land, not public lands as stated.

2. We concur with the recommendations in the report.

3. In the "Executive Summary" section, we find the following statement misleading. "Findings were compared with engineering criteria that are currently accepted by most private and public agencies engaged in dam design, construction, and operation." It is obvious that the hydrologic parameters used in this report do not represent the true drainage basin characteristics, but are merely indicators that a problem may exist. It is possible that a correct hydrologic study accompanied by a "dam break" flood routing routine could result in a conclusion that the dam is "safe." It is this quality of hydrologic analysis that is accepted by the profession and is in fact one of the recommendations in this report. This dam may be found to be "unsafe" after proper analysis, but to lable it as such in this report without qualification is unfair to the owner.

R.W. Larse

R. W. LARSE
Regional Engineer

PHOTO 1 Upstream slope in upper center near pickup, late summer, 1971

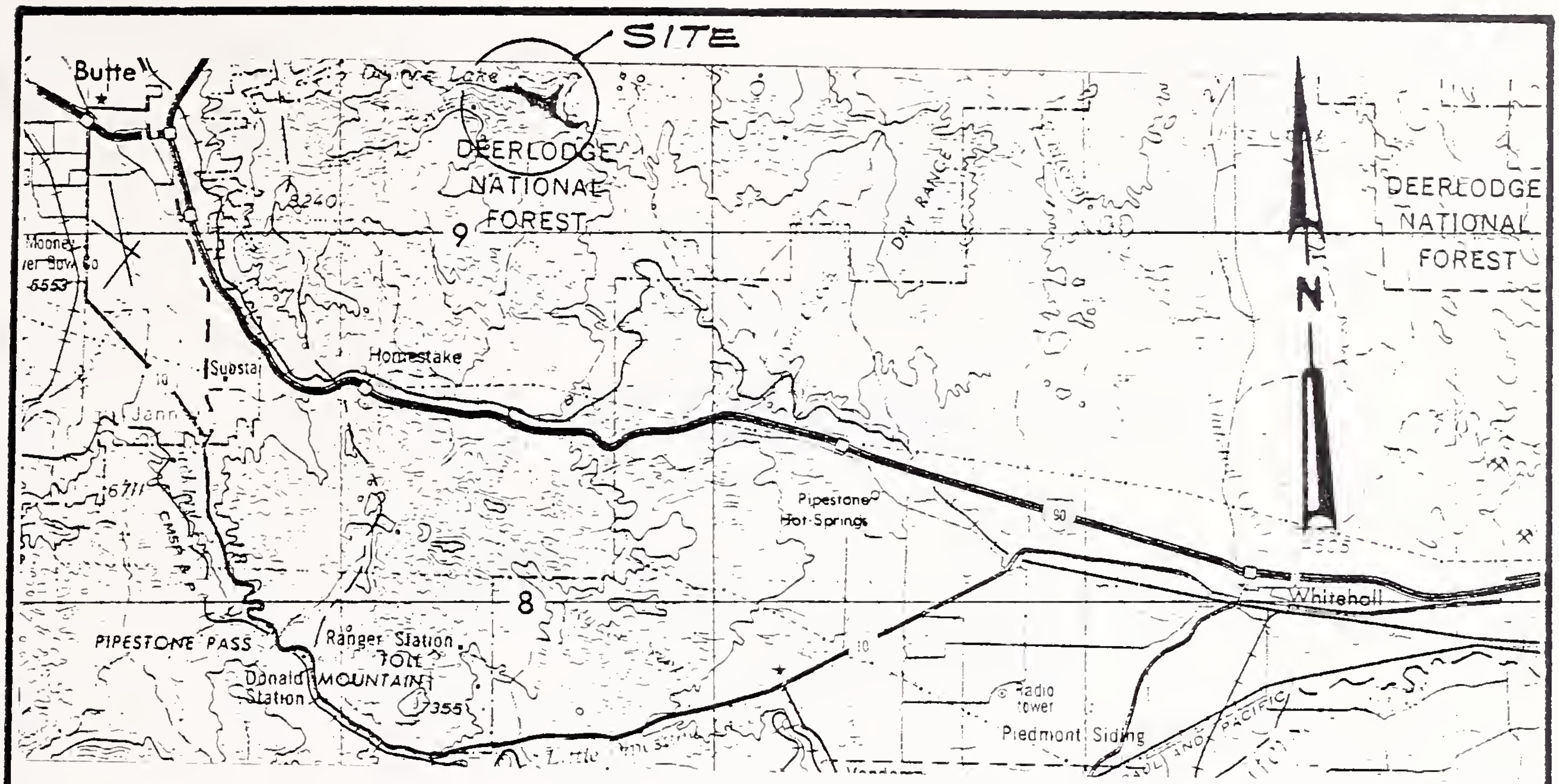
PHOTO 2 Gate tower, 7 June 1979

PHOTO 3 Gate tower, late summer, 1971

PHOTO 4 Spillway chute, looking downstream, (note dike on left) 7 June 1979

PHOTO 5 Spillway chute, looking upstream

PHOTO 6 Interstate 90 roadfill across Big Pipestone Creek, about 6.2 miles downstream of Delmoe Dam



PLAN

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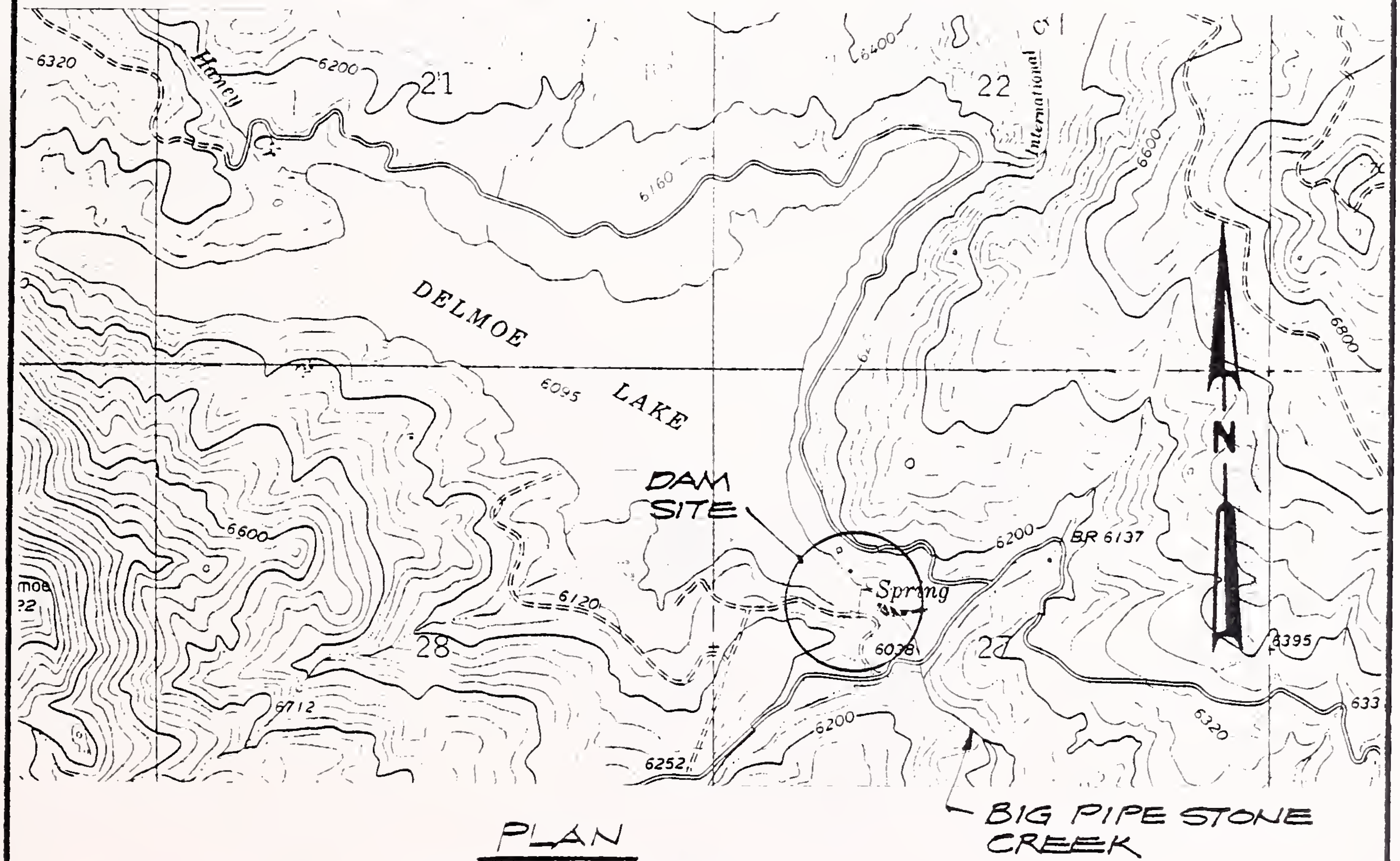
5 0 5 MILES



PLAN

SCALE 1:24000

0 1/2 1 MILE

PLATE 1

DELMOE LAKE DAM

VICINITY MAPS

CH2M HILL

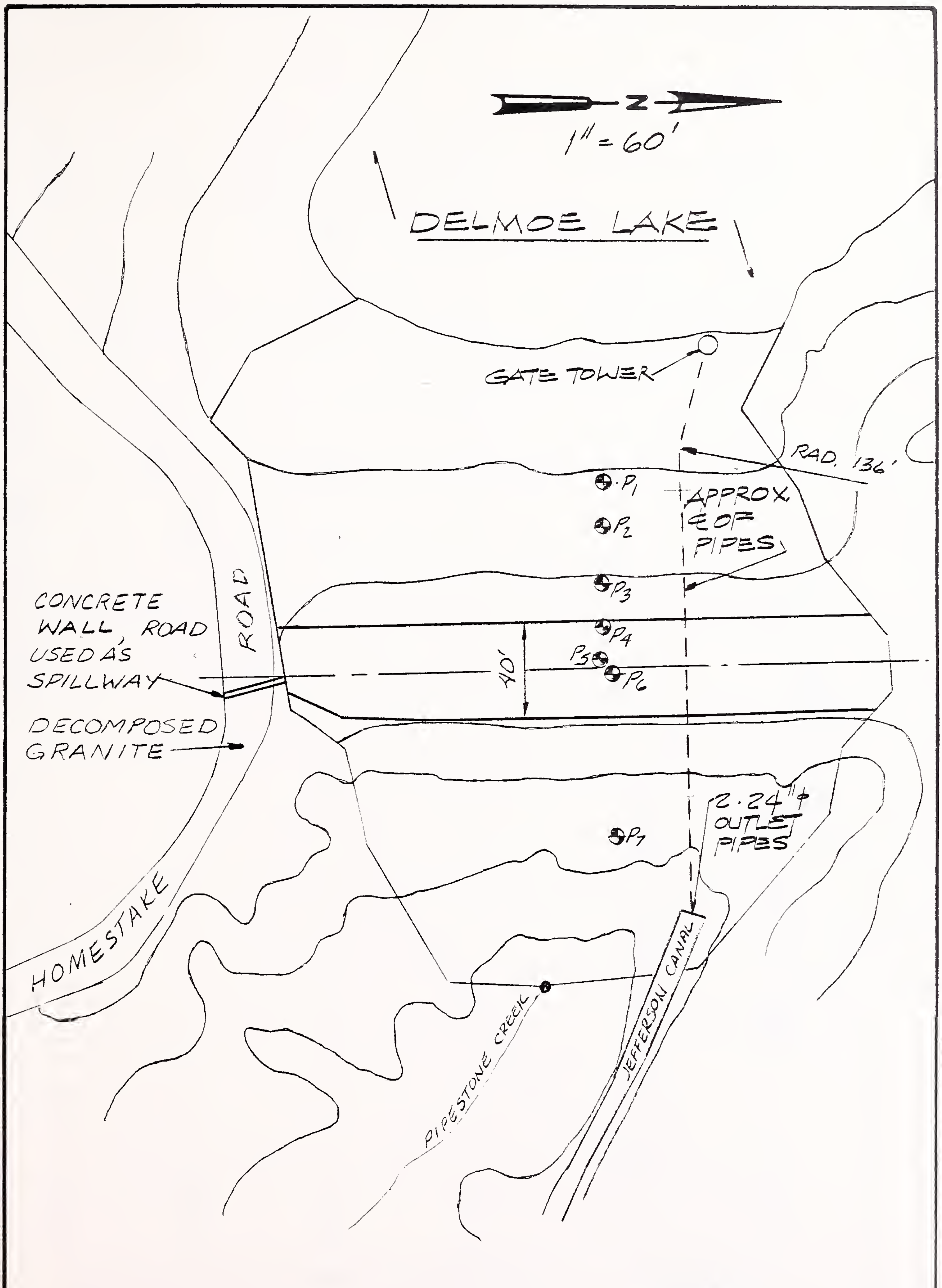


PLATE 2
DELMOE LAKE DAM
SITE PLAN

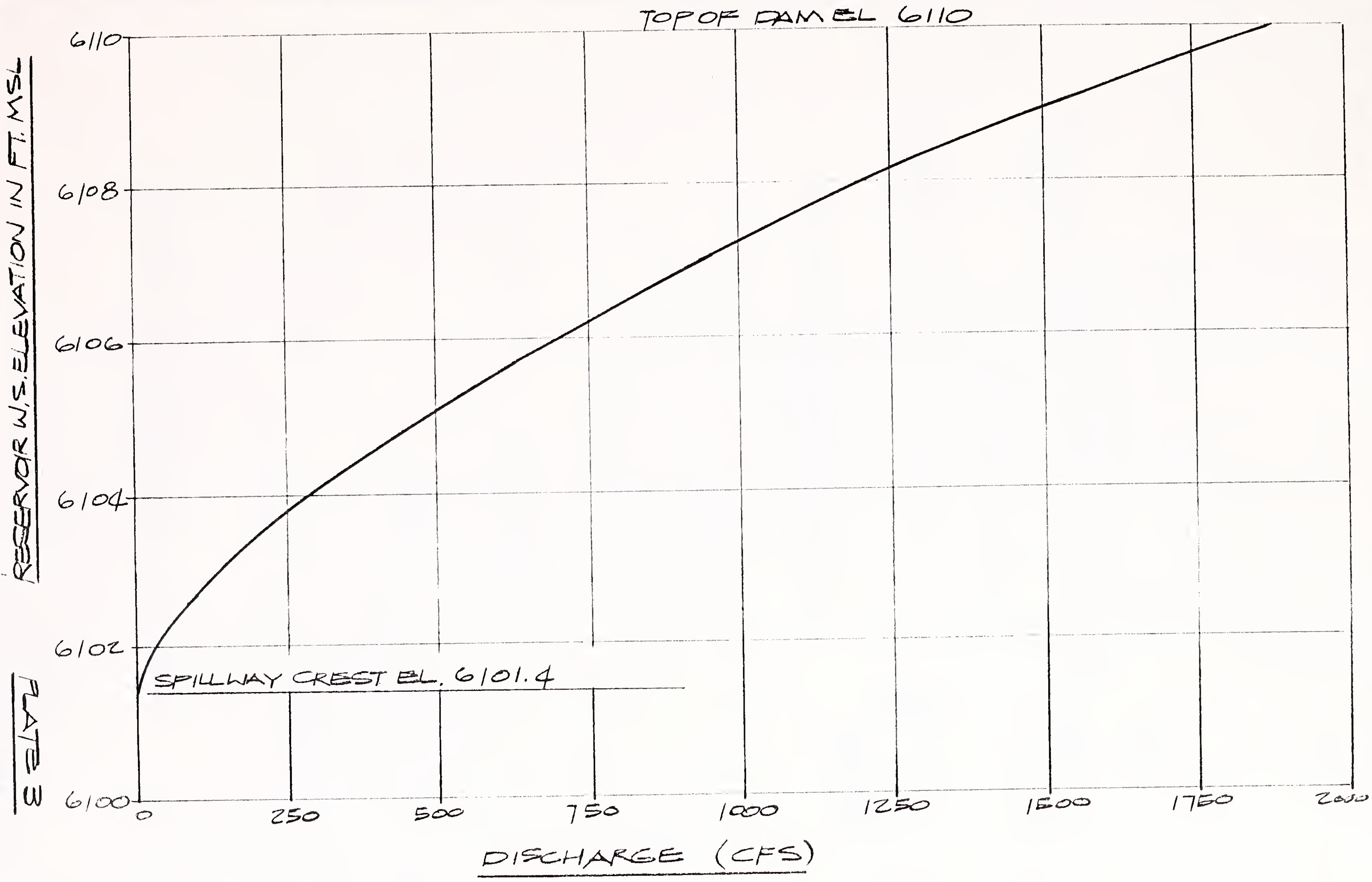
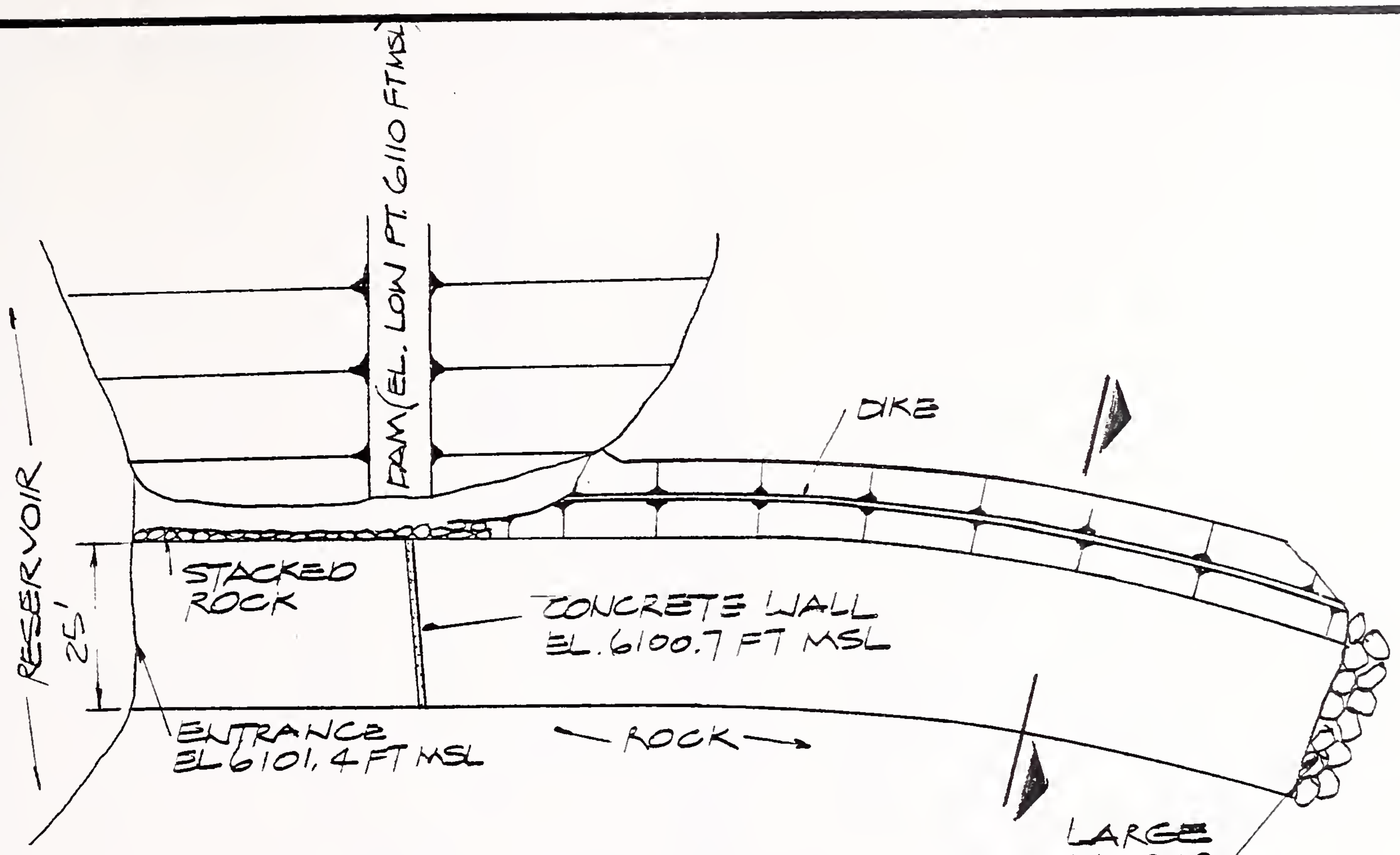


PLATE 3

DELMOB LAKE DAM

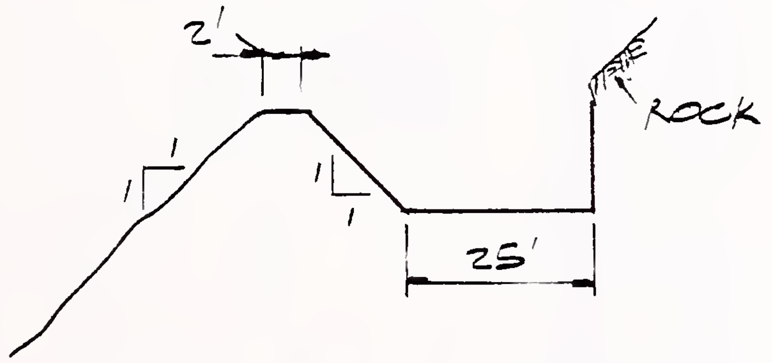
SPILLWAY RATING CURVE

CH2M HILL



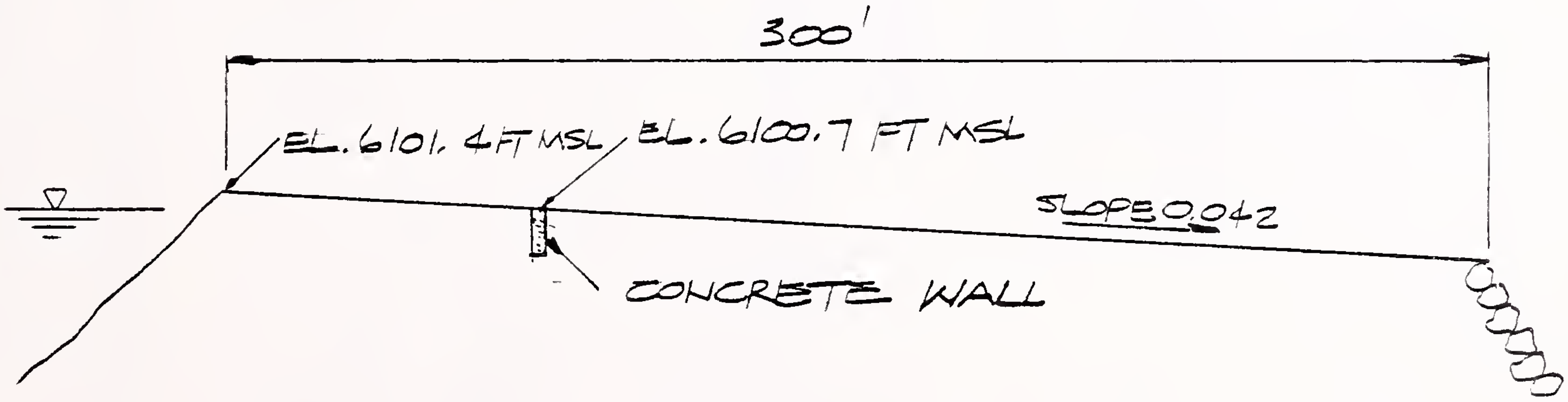
SCHEMATIC SPILLWAY PLAN

N.T.S.



SCHEMATIC SECTION

N.T.S.



SCHEMATIC SPILLWAY PROFILE

N.T.S.

PLATE 4

DELMOE LAKE DAM

SPILLWAY

CH2M HILL

NOTE:
FOOTBRIDGE TO TOWER SUSPENDED ON CABLE ATTACHED TO RESERVOIR SHORE

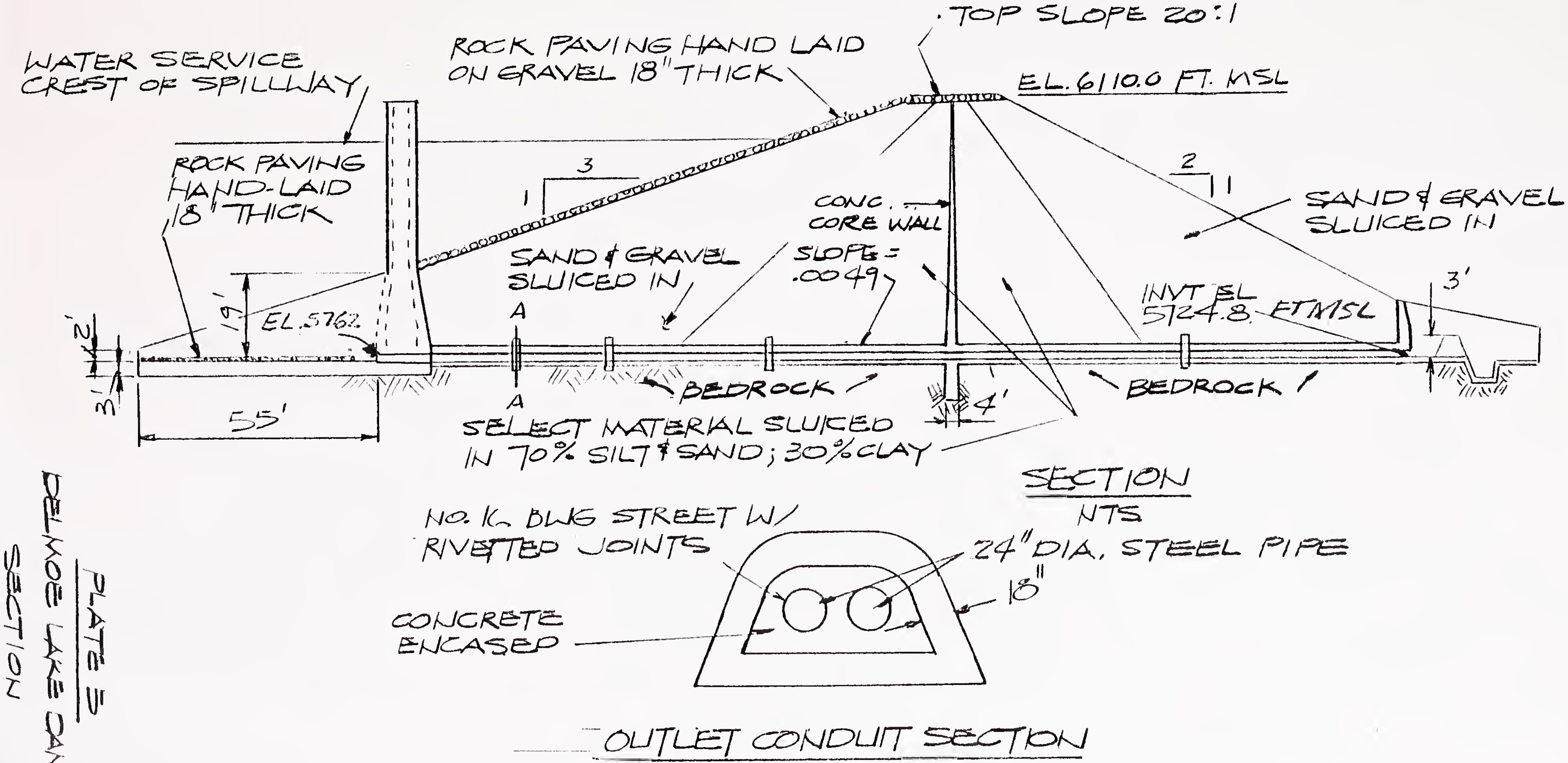


PLATE 3
DELMOE LAKE DAM
SECTION

CH2M HILL